

4100-0120P

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/701782

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP99/07102	September 23, 1999	October 26, 1998

TITLE OF INVENTION

A PROCESS FOR PROCESSING OFDM-SIGNALS RECEIVED SIMULTANEOUSLY BY A MULTI-ANTENNA SYSTEM

APPLICANT(S) FOR DO/EO/US

LAUTERJUNG, Juergen; BALZ, Christoph

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date
5. A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. has been transmitted by the International Bureau.
 - c. is not required, as the application was filed in the United States Receiving Office (RO/US).
6. A translation of the International Application into English (35 U.S.C. 371(c)(3)).
7. Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(2)).
 - a. are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. have been transmitted by the International Bureau.
 - c. have not been made; however, the time limit for making such amendments has NOT expired.
 - d. have not been made and will not be made.
8. A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. An Information Disclosure Statement under 37 CFR 1.97 and 1.98./International Search Report, 1449 Form w/references
12. An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. A **FIRST** preliminary amendment.
 A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. A substitute specification.
15. A change of power of attorney and/or address letter.
16. Other items or information:
German Search Report
Three (3) sheets of formal drawings.

09/701702

PCT/EP99/07102

4100-0120P

17. The following fees are submitted:**BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):**

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO. \$1,000.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO. \$860.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO. \$710.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4). \$690.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4). \$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =

Surcharge of \$130.00 for furnishing the oath or declaration later than 20 30 months from the earliest claimed priority date (37 CFR 1.492(e)).

CALCULATIONS PTO USE ONLY

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528 Rec'd PCT/PTO 04 DEC 2000

PATENT
4100-0120P

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: LAUTERJUNG et al.
Int'l. Appl. No.: PCT/EP99/07102
Appl. No.: New Group:
Filed: December 4, 2000 Examiner:
For: A PROCESS FOR PROCESSING OFDM-
SIGNALS RECEIVED SIMULTANEOUSLY BY
A MULTI-ANTENNA SYSTEM

PRELIMINARY AMENDMENT

BOX PATENT APPLICATION

Assistant Commissioner for Patents
Washington, DC 20231

December 4, 2000

Sir:

The following Preliminary Amendments and Remarks are respectfully submitted in connection with the above-identified application.

AMENDMENTS

IN THE SPECIFICATION:

Please amend the specification as follows:

Before line 1, insert --This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/EP99/07102 which has an International filing date of September 23, 1999, which designated the United States of America.--

IN THE CLAIMS:

Claim 4, lines 1 and 2, change "one of the preceding claims" to --claim 1--

REMARKS

The specification has been amended to provide a cross-reference to the previously filed International Application.

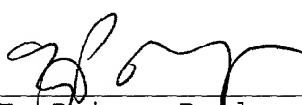
The claims have been amended merely to remove the improper multiple dependencies and to place the application into better form prior to examination.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By


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FPB/djm
4100-0120P

(Rev. 04/19/2000)

A Process for Processing OFDM-Signals Received
Simultaneously by a Multi-Antenna System

The invention relates to a process according to the preamble of the Main Claim.

In modern digital technology, so-called OFDM-systems

- 5 (Orthogonal-Frequency-Division Multiplex) or COFDM-systems (coded OFDM) are used for data transmission (sound, video or other data). In accordance with this principle, prior to transmission the digital data stream is split via a transmitter network into a plurality of sub-signals, each
- 10 of which is transmitted separately on an individual carrier. In the so-called DVB-T-system (Digital-Video-Broadcasting, terrestrial), which also serves for the transmission of data of a general type, 1705 or 6817 individual carriers are used for example. In the receiver
- 15 these items of subsidiary information are recombined to form a complete item of information of the transmitter-end digital data stream.

These OFDM-systems are standardized in terms of the

- 20 transmitting-end conditioning and receiving-end recovery of the data (for example in the DAB-standard ETS 300401 for DAB and in the standard ETS 300744 for DVB-T). It is a common feature of these OFDM-systems that at the receiving end the high-frequency signal received by an antenna is
- 25 demodulated in an OFDM-demodulator, preferably after conversion into an intermediate frequency, and in this way the associated I/Q-values are acquired for each individual carrier. In a so-called pilot-tone-corrected OFDM-system, as used in DVB-T, a channel correction value is determined
- 30 simultaneously from the co-transmitted pilot tones. For each individual carrier, each I/Q-value is complexly multiplied by the relevant channel correction value. This ensures that all the carriers have constant amplitudes, possible breaks in amplitude of individual carriers of the
- 35 overall reception band, caused for example by multipath

reception disturbances, being appropriately compensated and corrected.

In such systems, in addition to the individual data, it is
5 also common practice to transmit so-called confidence
values and thus to influence the further processing of the
acquired digital values in so-called soft-decision
processes. These two known possibilities of correcting the
I/Q-values via the channel correction or the obtained
10 digital values through the confidence values are state of
the art in receiver technology.

To improve the signal/noise ratio, in particular for the
mobile reception of such OFDM-signals, it is known to
15 provide a multi-antenna system with two or more antennae
and correspondingly assigned, separate receiving channels,
and to combine the analogue received signals in the
receiver in the HF- or IF-plane of this plurality of
receiving channels. The analogue signals of the individual
20 receiving channels are added, having been weighted in
frequency-dependent manner, for example as a function of
the received power. Here however not only the useful
signals but also the noise components are combined, which
in principle can even result in an impairment of the
25 signal/noise ratio compared to the most favourable
receiving channel for the relevant sub-band. These
analogue combining processes also require a very high
outlay and follow the relevant channel properties only
relatively slowly. In the case of frequency-selective
30 addition, they have only relatively flat selection curves,
i.e. sharp breaks in the receiving frequency range cannot
be corrected.

Therefore the object of the invention is to indicate a
35 process for combining OFDM-signals received simultaneously
by a multi-antenna system which avoids these disadvantages
and leads to a distinct improvement in reception.

Commencing from a process according to the preamble of the Main Claim, this object is achieved by the characterising features of the Main Claim. Advantageous further developments are described in the sub-claims.

5

In accordance with the invention, in each individual receiving channel of the multi-antenna system, the values for channel correction or confidence anyhow acquired therein according to the relevant standard are used for a corresponding weighting of the demodulated I/Q-values. In the DAB-system, in which the confidence values are determined in known manner, these can be used in accordance with the invention to add the relevant I/Q-values in an appropriately weighted manner and thus, from the relevant receiving branches having a good signal/noise ratio for the received signal, to obtain a corresponding mean value of the individual received signals of the multi-antenna system, which is particularly advantageous for the mobile reception of DAB-signals where, due to the properties of the transmission channel, a more difficult reception situation exists than in the case of stationary reception. In this way fading disturbances can be corrected.

It is particularly advantageous to perform this correction as a function of the channel correction values as provided in the DVB-T-system. Here again, mobile reception with a good signal/noise ratio is possible, this weighted evaluation of the received signals in the individual receiving channels facilitating a particularly simple analysis algorithm.

In the following the invention will be explained in detail in the form of two exemplary embodiments making reference to schematic drawings.

35

Figure 1 is the fundamental circuit diagram of a receiving arrangement for processing pilot-tone-supported OFDM-

signals in which the signals of the individual carriers of the multi-antenna system are digitally combined upstream of the decision device. The received multicarrier OFDM-signals are received via a plurality of antennae A1 to An
 5 and can optionally be converted into a suitable intermediate frequency via individual receivers E1, E2 to En. All the receivers E1 to En are set at the same receiving frequency and for simplicity the down-conversion into the intermediate frequency optionally can be performed
 10 using a common oscillator. Then, in each of the n receiving channels, the demodulation of the OFDM-signals is in each case performed in separate demodulators D1 to Dn and at the same time the associated channel correction values are also acquired, these being a gauge of the level
 15 of the individual carriers of the multicarrier system and thus also a gauge of the probability that the symbol transmitted with this carrier is correct.

The I/Q-values available for each individual carrier at the
 20 output of the demodulators are fed to a time synchronisation device S, in which possible time offsets of the total number n of I/Q-signals are corrected by corresponding delay devices so that the I/Q-values of corresponding carriers occur simultaneously at the output
 25 of this time synchronisation device S, which values are then fed to a processing device R and processed therein as will be described in the following. The time synchronisation can be performed using synchronisation flags known in association with OFDM demodulators.

30 Before the I/Q-values, thus conditioned in known manner, are reduced to individual bits in the decision (demapping) device M, in the processing device R they are complexly multiplied by a value k proportional to the reciprocal
 35 value of the relevant channel correction, and thus are weighted. This weighting is firstly performed individually for each I/Q-value for all n receiving channels. The I/Q-

values are thus weighted particularly high if they are changed as little as possible by the channel correction. Then all the mutually assigned I/Q-values are added and divided by the sum of all the weights. Figure 2

5 illustrates this type of weighting and addition for two antennae A1 and A2. Of the total of 1705 or 6817 individual carriers of the system, at the frequency f_1 the received carrier is received only with a reduced amplitude via the antenna A1 due to fading. This is expressed by the 10 reciprocal value k_1 of the channel correction obtained for this receiving channel. The carrier at the frequency f_1 is thus weighted with a relatively low weight, for example only with the channel correction value 2, while the carriers in the range below and above the frequency f_1 , 15 which are received at the full level, are weighted very high, for example with the weight 10. In the case of the antenna A2 this low weighted receiving range lies at a different location at the frequency f_2 .

20 When the I/Q-values, differently weighted in this way with for example 2 and 10 in the f_1 range, are now added and finally divided by the total number of all the weights (in the example 12), a mean value is obtained which has a constant good reception value over the entire frequency 25 range. The averaged I/Q-values thus obtained in the processing device R are then fed to the decision device M and further analyzed therein in known manner. Optionally, the confidence of the information can also be calculated therein. Then the data are further processed in a 30 conventional Viterbi-decoder V with soft decision.

Figure 3 illustrates an exemplary embodiment of a receiving arrangement for processing OFDM-signals in a multi-antenna system by digital combination downstream of the decision 35 device M. In many cases the I/Q-values are available for further processing not upstream of the decision device but only downstream of the decision device M, which in this

case for example is integrated in the demodulator D1 for each individual receiving channel. Thus the data words reduced to individual bits are already available at the output of the demodulator and indeed together with the 5 confidence values which have likewise been calculated in the decision devices M1 to Mn and which, following the time synchronisation in the time synchronisation device S, are weighted and further processed in the processing device R as follows.

10

Each individual data word of the n receiving channels is reduced to the original I/Q-values using a suitable algorithm. The thus obtained, corresponding I/Q-values are then complexly multiplied by the value of the relevant 15 confidence information, whereupon all the thus weighted I/Q-values are added again as described in association with Figure 2 and then divided by the number of all the weights. When the I/Q-values have been reduced to the data bits, the thus determined mean value of all the I/Q-values is then 20 fed again to the Viterbi-decoder with soft decision V and further processed.

New Claims

1. A process for processing OFDM-signals received simultaneously by a multi-antenna system with a plurality of separate receiving channels, characterised in that in the receiving channels, in a manner known per se, the 5 channel correction values or the confidence values are determined from the pilots for each carrier of the OFDM-signal, from which values weighting factors are derived with which the I/Q-values of each individual carrier or OFDM-signal obtained in the OFDM-demodulator are 10 differently weighted such that carriers received at a low level are weighted low and carriers received at a high level are weighted high, and the thus weighted I/Q-values are then added and divided by the sum of all the weighting factors.

15

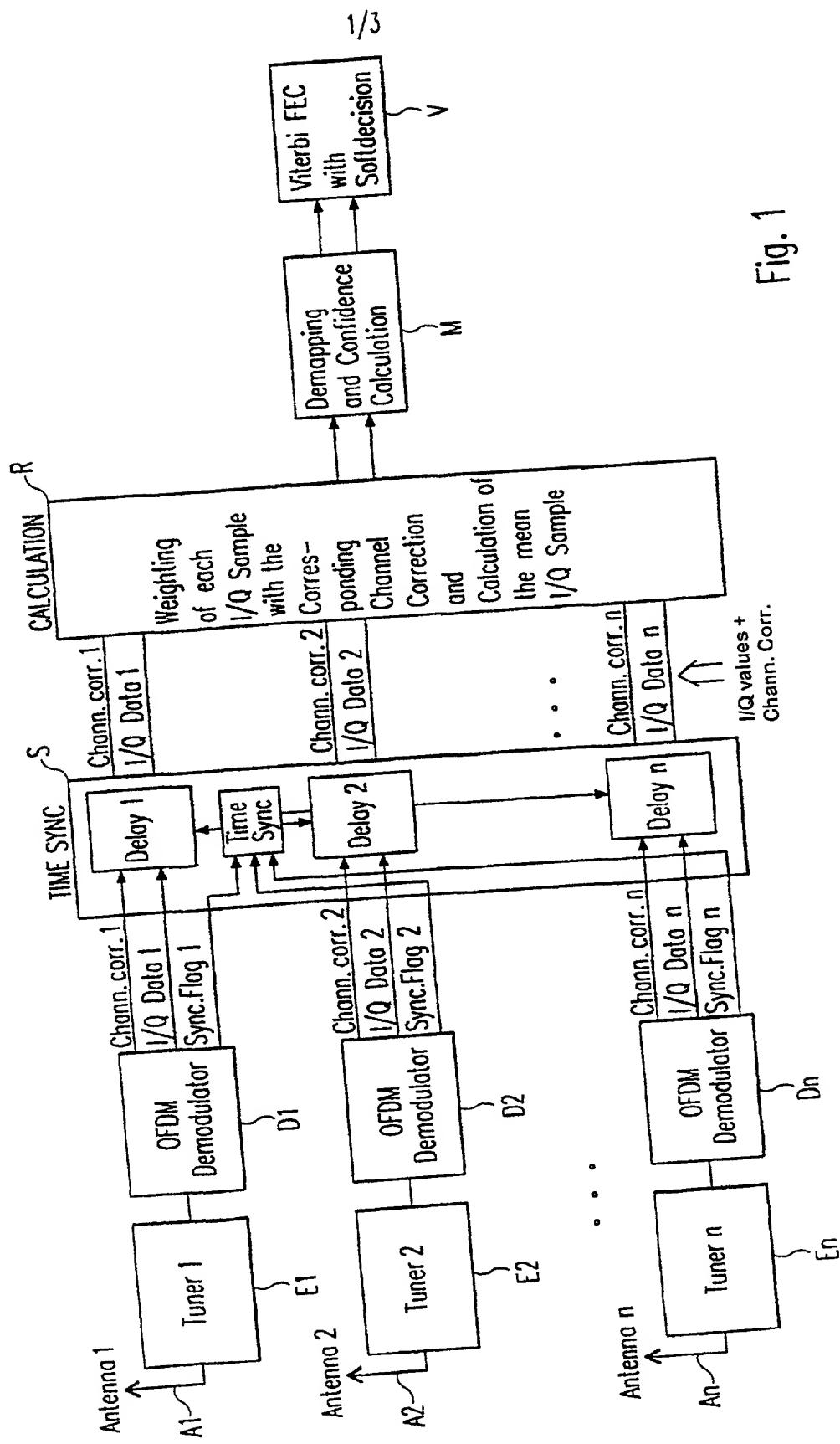
2. A process according to Claim 1, characterised in that the I/Q-values at the output of the demodulator are fed to a time synchronisation device so that the I/Q-values of corresponding carriers of the individual receiving 20 channels are in each case simultaneously available for further processing.

3. A process according to Claim 1 or 2, characterised in that the I/Q-values of each individual 25 carrier of the OFDM-signal are weighted as a function of the channel correction values obtained from the pilots, such that low weighting factors are selected for large channel correction values and high weighting factors are selected for small channel correction values.

30

4. A process according to one of the preceding claims, characterised in that the data words available downstream of the decision device are reduced to their original I/Q-values and then complexly weighted with the 35 confidence values.

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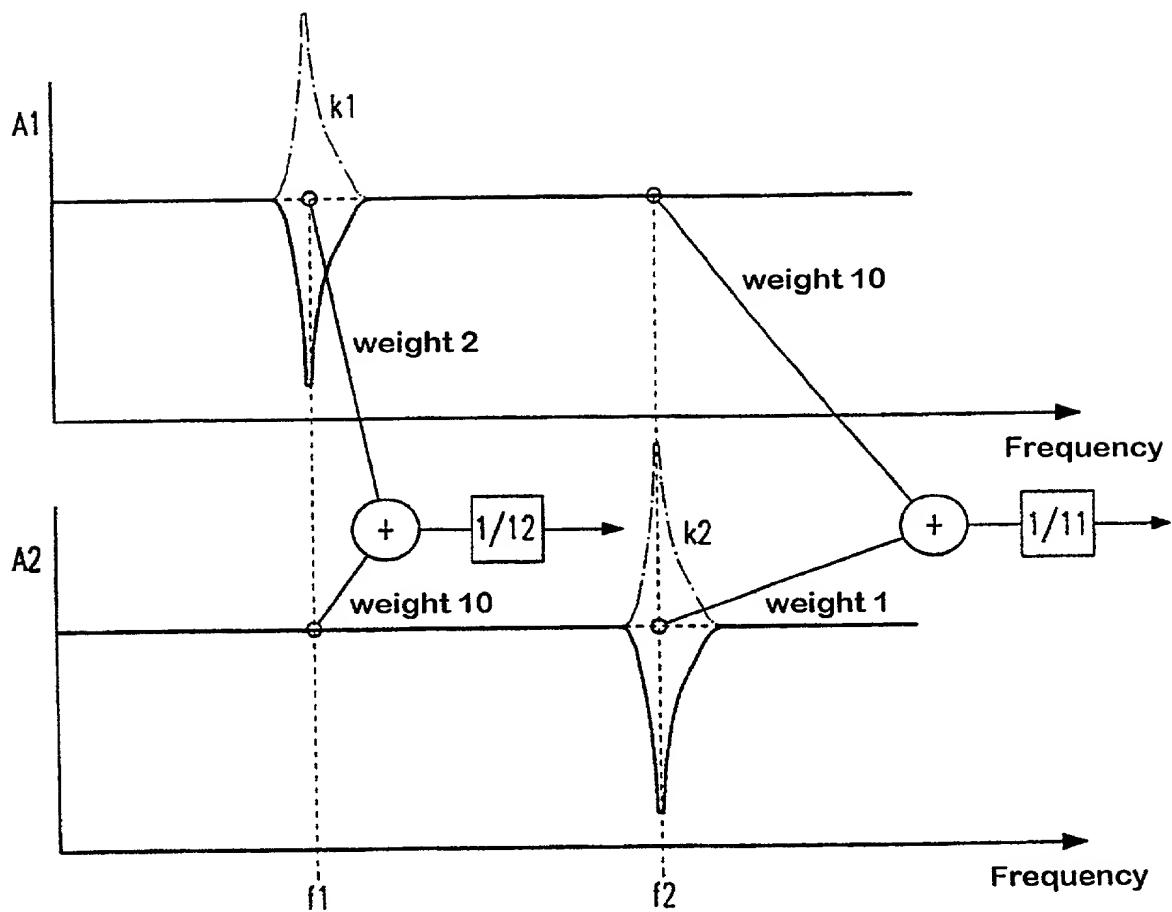


Fig. 2

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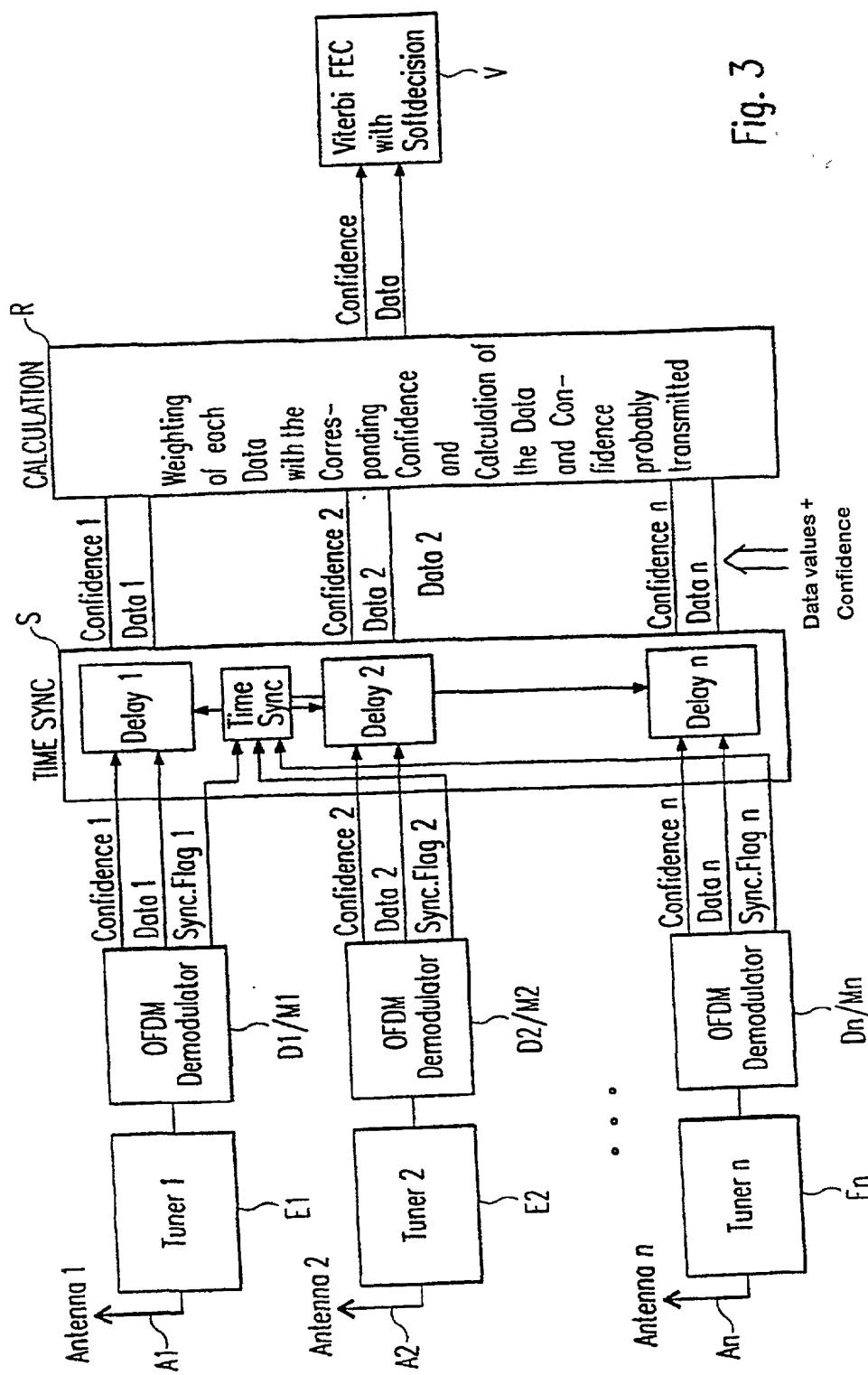


Fig. 3

German Language Declaration

Prior foreign applications / Priorität beansprucht

(6) 198 49 318.5
(Number)
(Nummer)GERMANY
(Country)
(Land)26/OCT/1998
(Day/Month/year Filed)
(Tag/Monat/Jahr eingereicht)
[X] Yes Ja
[] No Nein(6)
(Number)
(Nummer)(Country)
(Land)[]
(Day/Month/year Filed)
(Tag/Monat/Jahr eingereicht)
Yes Ja
No Nein(6)
(Number)
(Nummer)(Country)
(Land)[]
(Day/Month/year Filed)
(Tag/Monat/Jahr eingereicht)
Yes Ja
No Nein

Ich beanspruche hiermit gemäß Absatz 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 119(e), den Vorzug aller unten aufgeführten vorläufigen Anmeldungen.

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below.

(7)
(Application Serial No.)
(Anmeldeseriennummer)(Filing Date)
(Anmeldedatum)(7)
(Application Serial No.)
(Anmeldeseriennummer)(Filing Date)
(Anmeldedatum)

Ich beanspruche hiermit gemäß Absatz 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 112 offenbart ist, erkenne ich gemäß Absatz 37, Bundesgesetzbuch, Paragraph 1.56 meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(8)
(Application Serial No.)
(Anmeldeseriennummer)(Filing Date)
(Anmeldedatum)(Status)
(patentiert, anhangig, aufgegeben)
(Status)
(patented, pending, abandoned)(8)
(Application Serial No.)
(Anmeldeseriennummer)(Filing Date)
(Anmeldedatum)(Status)
(patentiert, anhangig, aufgegeben)
(Status)
(patented, pending, abandoned)

Ich erkläre hiermit, daß alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und daß ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, daß wissentlich und vorsätzlich falsche Angaben gemäß Paragraph 1001, Absatz 18 der Zivilprozeßordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden können, und daß derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patents gefährden werden.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**Declaration and Power of Attorney For Patent Application
(or PCT) Erklärung Für Patentanmeldungen Mit Vollmacht**

German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

daß mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeföhrten Angaben entsprechen,

daß ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeföhr sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

(1) A PROCESS FOR PROCESSING OFDM-SIGNALS

**RECEIVED SIMULTANEOUSLY BY A MULTI-
ANTENNA SYSTEM**

deren Beschreibung hier beigefügt ist außer das folgende Feld ist angekreuzt: (zutreffendes ankreuzen)

(2) vorhergehend eingereicht

(3) am _____ unter der

(4) U.S. Anmeldungsseriennummer _____
der PCT International No. _____
und (5) wurde am _____
abgeändert (falls tatsächlich abgeändert).

Ich bestätige hiermit, daß ich Inhalt der obigen Patentanmeldung einschließlich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56 von Wichtigkeit sind, an.

Ich beanspruche hiermit auslandische Prioritätsvorteile gemäß Abschnitt 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfinderurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

(1)

the specification of which is attached hereto unless the following box is checked: (check appropriate blocks)

(2) was filed _____

(3) on _____ as

(4) U.S. Appln. S. N. _____

or PCT International No. _____

(5) as amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

German Language Declaration

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den Patentanwalt (oder die Patentanwälte) und/oder Patent Agenten, **Kundennummer 2292**, mit der Abwicklung aller damit verbundenen Geschäfte vor dem Patent- und Warenzeichen: (Aktuellen Namen und aktuelle Registrationsnummer anführen,)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the attorney(s) and/or agent(s) of **Customer No. 2292** to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list current names and registration numbers).

Raymond C. Stewart, Reg. No. 21,066
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 Charles Gorenstein, Reg. No. 29,271
 Leonard R. Svensson, Reg. No. 30,330
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 John W. Bailey, Reg. No. 32,881
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 Marc S. Weiner, Reg. No. 32,181
 Donald J. Daley, Reg. No. 34,313
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Send Correspondence to address of
Customer No. 2292, currently:

Birch, Stewart, Kolasch & Birch, LLP
 P.O. Box 747
 Falls Church, Virginia 22040-0747

Voller Name des ersten Erfinders:

Full name of first inventor:

(9) Juergen LAUTERJUNG

Unterschrift des ersten Erfinders

Datum

Signature of first inventor

Date

Juergen Lauterjung 20.12.2000

Wohnsitz

Residence

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Staatsangehörigkeit

Citizenship

German

DE

Postanschrift

Post Office Address

same

200
Voller Name des zweiten Erfinders:

Full name of second inventor:

(9) Christoph BALZ

Unterschrift des zweiten Erfinders

Datum

Signature of second inventor

Date

Christoph BALZ

20.12.2000

Wohnsitz

Residence

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Staatsangehörigkeit

Citizenship

Germany

DE

Postanschrift

Post Office Address

same

Voller Name des dritten Erfinders:

Full name of third Inventor:

(9)

Unterschrift des dritten Erfinders

Datum

Signature of third Inventor

Date

Wohnsitz

Residence

Staatsangehörigkeit

Citizenship

Postanschrift

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